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An Empirical Study of the Geospatial Availability of Hospitals in Imo East using GPS Mapping

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ABSTRACT

The accessibility of hospital facilities contributes to social stability and the protection of the fundamental human right to health care. This study aimed to examine the geographical distribution of hospital care facilities and their attribute information in the nine Local Government Areas (LGA) of the Imo East District by developing a database and producing a visual map of these facilities. The facilities investigated were divided into different groups by type, ownership, and operational state. The attribute data that makes up the database was obtained through questionnaires distributed to facility management. Geospatial data was collected using a handheld Global Positioning System (GPS). The maps received from the government agencies integrated with the ArcGIS environment were used for the visual mapping of the facilities. Statistical Package for the Social Sciences (SPSS) was used to analyze the data. The results suggest that there are 837 health facilities, with Ahiazu and Ezinihitte having the fewest (8.1 and 8.5%, respectively), and Ngor-Okpala having the most sparsely distributed. The areas with the most facilities are Aboh and Ikeduru, with 13.3 and 13.0%, respectively. The ownership of private and public facilities was 59.3% and 40.7%, respectively. The facilities are not evenly dispersed, and their standards vary substantially. The database created would surely aid in management, planning, and encouraging new avenues in health administration. The visual map produced illustrates the locations of health institutions, and road connectivity by type, and is an essential source of health information. The visual map available to the public can increase the number of patients who travel to the proper hospitals and prevent patients from seeking health treatment in the wrong place. As a result, the findings of this study may aid in the administration of health facilities and future planning.

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INTRODUCTION

Regardless of the country's or society's level of development, human health has been a key aspect in the sustainable development of society. Healthcare facilities provide treatment to the community. These facilities provide various medical services to the public. There has been a restoration of enthusiasm for mapping health facilities (Audu and Lawan, 2021; Sagir et al., 2021; Sunday et al., 2022). These facilities can be distinguished among clinics, maternity, health care center, health post, and specialist hospital (Adewole et al., 2022). Also, distinctions are made between the service providers such as public or private healthcare facilities, especially within the populace.

Every aspect of our daily life makes use of the GIS. The ability of GIS to collect, modify, store, analyze, and visualize geo-referenced data provides the chance to develop a realistic picture of the world and a chance to predict future events, and it has become very popular when presented in the form of digital maps (Kerr et al., 2011; Schweiger, 2022; Zhou, 2021). Geographical information system (GIS) research emphasizes the spatial accessibility, and GIS research in the healthcare field focuses on the methodological development of geographic accessibility to maximize access to healthcare (Shanmathi Rekha et al., 2017). The spatial pattern of healthcare facilities refers to how the facilities are organized over a geographical area.

Healthcare is one of the 17 global objectives created by the United Nations to alter our world (Bernstein, 2017; Rasche, 2020). Access to healthcare is one of the most important services for the entire population of the country. Many studies are being done to enhance access to healthcare and decrease inequities. Norheim et al. (2015), identified inequalities in geographic access to health care as one of the primary challenges in achieving the 3rd SDG likewise other studies by Cheng et al., (2020) and do Nascimento Silva and Padeiro (2020). Regardless of the country's or society's level of development, human health has been a key aspect in the sustainable development of society (Nazar et al., 2022).

Digital mapping has now emerged as a critical method for addressing a wide range of environmental issues. Surveyors, Scientists, Engineers, developers, and resource managers now have the prospect to distill and combine large sets of spatial data into useful information, providing new perspectives and novel approaches to problem-solving. This study evaluates the distribution of Health Facilities in each of the nine (9) LGA of Imo East Senatorial Zone using GIS. The density, types, and ownership status of healthcare facilities available to users would be established. These information catalogs the percentage ownership between individuals, charity organizations, and various levels of government intervention and world bodies, the functionality and registration status, and specialization of these facilities were evaluated in the study in the Imo East Senatorial Zone. The targets is providing would-be investors and operators of the healthcare facilities, with optimum site selection which will undeniably be cost-saving on capital strategy.

Methodology

The study encompasses all the nine local government areas of Aboh, Ahiazu, Ezinihitte, Ikeduru, Mbaitolu, Ngor-Okpala, Owerri Municipal, Owerri North, and Owerri West of Imo State. The study area lies within a total area coverage of 5,530 km^2 (2,140 sq mi) and a population of 1,919,600 (NDHS, 2008, PRB 2015). Satellite maps of these LGAs were obtained from GoogleMaps™. Handheld Garmin 60 GPS, AutoCAD 2020, ArcGIS 10.5 software, and questionnaires enquiring on the attributes of each health facility are the materials and equipment deployed during the study. In addition, secondary data on healthcare facilities were collected from various health organizations like the Nigeria Health Facility Registry (HFR) and the Ministry of Health. The maps obtained from Google Maps™ were used as the base maps. However, it was not detailed, they were however updated by globe-trotting, site visits to the existing street map, and using maps acquired from the government agencies involved in rural and urban developments. The procedure included correcting the naming of major roads and then incorporating various minor and access roads that do not exist on Google Maps (Abubakar and Ibrahim, 2021).

Questionnaires were issued to each of the facilities to obtain their attribute information. The information acquired included the name of the health facility, community location, functionality status, and classification for example specialist hospital, clinic, health post, dispensary, maternity etc. Others include ownership for instance public or private. The coordinates of each health facility were obtained using the GPS. These were georeferenced on the Google satellite image using AutoCAD software. On-screen digitization was done using ArcGIS 10.5. This was to produce features such as roads digitized as dotted lines, boundaries as bold lines, and Health Facilities classifications as indicated in the legends of the maps. The data were structured in layers, and the SPSS was used to create tables that categorized the spatial data. Among the categories were ownership, functionality, type of facilities, and location. These could answer questions like: 1) How many healthcare facilities are public/private in each LGA? 2) How many public/private health centers are in the communities of each LGA? 3) How many of these facilities are functional in each LGA?

Data collected from NBS and NPC information dump detailed the following attributes of each LGA in the study. Aboh, Amohuru, Eziala, Ezuhu, Umaumadi, and Egberede are just a few of the cities and communities that make up Aboh Mbaise, which has a total size of 183.0 km^2. The estimated population of Aboh Mbaise is 270,700. The total size of the Ngor Okpala LGA is 523.1 km^2. Ngor Okpala LGA is made up of the towns and villages of Umuohiagu, Alulu, Eziama, Imerienwe, Ngali, Oburu, Ntu, and Nnorie. Ngor Okpala LGA's estimated population is 219,400. Several cities and villages make up Ahiazu Mbaise LGA, including Akabor, Ogbe, Obodo-Ujichi, Ihitte Afor, Oru Ahiara, and Oparaaadim. Ahiazu Mbaise has a total area of 99.6 km^2 and an estimated population is 237,400. Oboama, Okpofe, Obizi, Ihite, Amaumara, Akpodim, Ezi udo, and Chokonaeze are just a few of the towns and communities that make up the Ezinihitte Mbaise local government area in Imo state has a total area of 113.7 km^2 and 234,600 people living in Ezinihitte Mbaise, according to estimates.

The estimated population of Ikeduru LGA is 208,100 inhabitants. Ikeduru LGA has a total land area of 176.5 km^2. Towns and villages that makeup Ikeduru LGA include Amakohia, Inyishi, Amaimo, Umudum,

Uzoagba, Ikembara, Atta, and Akabo. Mbieri, Ogwa, Ogbaku, Umunoha, Ifakala, Orodo, Afara, and Ubomiri are among the towns and villages that comprise Mbaitoli LGA. Mbaitoli LGA has an estimated population of 330,100 people. Mbaitoli LGA has a land area of 173.4 km^2. The Owerri Municipal LGA has a population of 174,200 people and covers an area of 62.4 km^2. Owerri North LGA covers an area of 167.3 km^2. Egbu, Naze, Emekuku, Emii, Ihite, Ogada, Oha, Umuofor, and Umuayalu are among the towns and villages in the LGA. The current estimated population of Owerri North LGA is 245,100 people. Nekede, Irete, Avu, Ndegwu, Amakohia, Ihiagwa, Obinze, and Okuku are among the towns and villages in the LGA. The estimated population of Owerri West LGA is 141,400 people. Owerri West LGA covers an area of 286.8 km^2.

Results

From the data on the healthcare facilities, a database of their location was generated and summarized in Table 1. The locations captured at the survey totaled 837 healthcare facilities; 348 secondary and 489 primary facilities. Private hospitals accounted for 496 out of which 77 were owned by the missionaries and 341 were public facilities. The functional facilities were 771 representing 92.6 percent of the total facilities surveyed. An exploratory spatial data analysis was done to determine the distribution of the healthcare facilities in each of the LGAs, Kernel density mapping, normal distance analysis, and directional distribution analysis, was carried out. The health facilities recorded in Aboh were 111 spread across 19 communities, the majority (36%) in Nguru alone and 13 of these in Enyiogugu. The primary facilities were 74 in number. The missionaries had 13 of these facilities. The functional facilities were 102 representing 91.9% of the total facilities.

The Aboh LGA distribution is represented in Figure 1(a). It was found that most of the healthcare facilities in the Aboh are concentrated around the north-central locations of the LGA namely; Lagwa, Enyiogugu, Okwu-Nguru communities, and the Nkwogwu axis. From directional distribution analysis, it appeared that the distribution skewed towards clustering along the major roads traversing the LGA, which is indicative of the higher distribution of healthcare. This is largely attributed to the very high population density in the more urbanized areas compared to the interior communities of the LGA.

The health facilities recorded in Ngor-Okpala were 103 spread across 45 communities, Imerienwe had nine of these facilities. Alulu has six, Amala, Eziama, Ngor, Okpala had five facilities each. The number of primary facilities was 61 and 53 privately owned. The 94 facilities were functional. It was observed from the nearest-neighbor analysis that the locations of healthcare facilities are significantly spatially clustered among themselves. The distribution of the Ngor-Okpala LGA is shown in Figure 1(b).

Table 1: Summary of healthcare facilities by type, ownership and functionality across the LGA's of Owerri Zone

LGA	Type of facilities		Ownership of facilities			Functional facilities	Total number of facilities
	Primary	Secondary	Missionary	Private	Public		
Aboh	66	45	13	61	37	102	111
Ahiazu	36	32	5	35	28	66	67
Ezinihitte	42	29	6	29	36	67	70
Ikeduru	64	45	9	55	45	99	109
Mbaitoli	55	27	7	42	33	79	81
Ngor Okpala	64	39	12	46	45	94	103
Owerri Municipal	61	47	10	51	47	97	103
Owerri North	45	50	9	56	30	85	95
Owerri West	56	34	6	44	40	82	90
Total	489	348	77	419	341	771	837

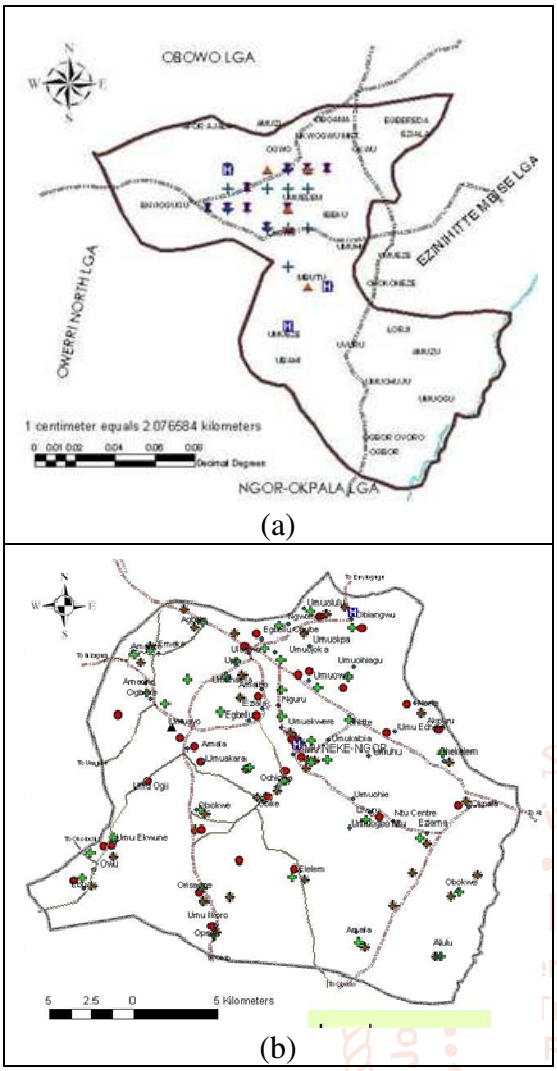


Figure 1: Locations of existing healthcare facilities in different communities of Aboh and Ngor-Okpala LGAs

The northern communities were discovered to have the majority of the LGA's healthcare services. The distribution also seemed to be spread out along the main roads that cross the LGA, according to directional distribution analysis, which is a sign of a higher distribution of healthcare. The closest neighbor analysis revealed that healthcare facility sites are highly geographically grouped and dispersed.

The health facilities recorded in Ahiazu were 68 spread across 33 communities, Obohia and Amuzi had six and five facilities respectively. Umuokirika, Oru, Oparanadim had four facilities each. The primary facilities had 54.4% of the recorded facilities. The functional facilities were 66 representing 97% of the total facilities. Figure 2(a) depicts the Ahiazu LGA distribution. It was found that most of the healthcare facilities in the LGA are concentrated around two areas Obodo-Ahiara, Obodo-Ujushi, and Lude axis, and Afor-Oru, Umuokirika, and Ekeokwe axis. From directional distribution analysis, it similarly appeared that the distribution also skewed towards clustering along the major roads traversing the LGA. It was observed from the nearest-neighbor analysis that the locations of healthcare facilities are significantly spatially clustered among themselves. The health facilities recorded in Ezinihitte were 71 spread across 18 communities, the majority (14.1%) in Onicha and Obizi 12.7%. The primary facilities were 42 in number. The missionaries had six of these facilities. The functional facilities were 67 representing 94.4% of the total facilities. The distribution of facilities in the Ezinihitte LGA was shown in Figure 2(b). The majority of the medical facilities in the LGA are dispersed among the localities, it was discovered.

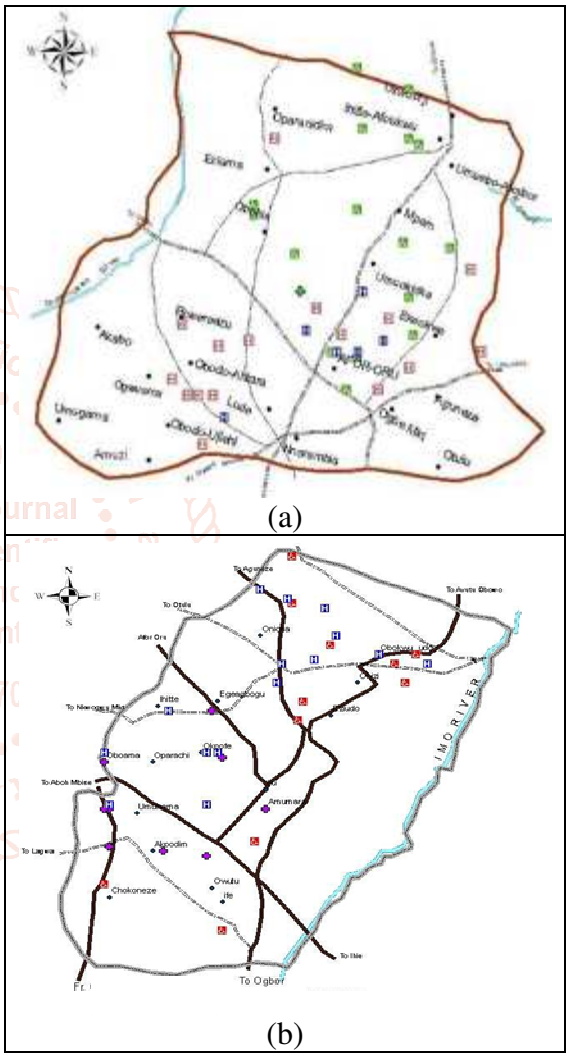


Figure 2: Locations of existing healthcare facilities in different communities of Ahiazu and Ezinihitte LGAs

While it was found from the nearest neighbor analysis that the locations of healthcare facilities are noticeably not clustered among themselves, it appeared from the directional distribution analysis that the distribution was similarly skewed towards clustering along the main roads traversing the LGA. In Ikeduru, there were 109 health facilities spread across 27 communities, with the majority (11.9%) in Iho, Amaimo, and Inyishi (9.2%) each. There were 64 primary facilities. 99 of the total facilities, or 90.9% of them, were functional. In Ikeduru, there were 109

health facilities spread across 27 communities, with the majority (11.9%) in Iho, Amaimo, and Inyishi (9.2%) each. There were 64 primary facilities. 99 of the total facilities, or 90.9% of them, were functional.

Figure 3 depicts the findings of a location coverage analysis for existing healthcare facilities in the LGAs of Mbaitoli and Ikeduru. Based on this research, it is obvious that all of the districts in the area are adequately covered and connected with existing healthcare facilities. This may be ascribed to proper facility site location and good road network connectivity in the inner border areas.

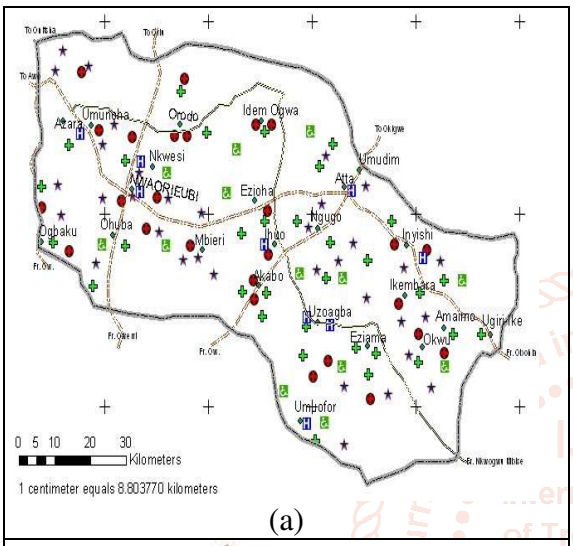


Figure 3: Locations of existing healthcare facilities in different communities of Mbaitoli and Ikeduru LGAs

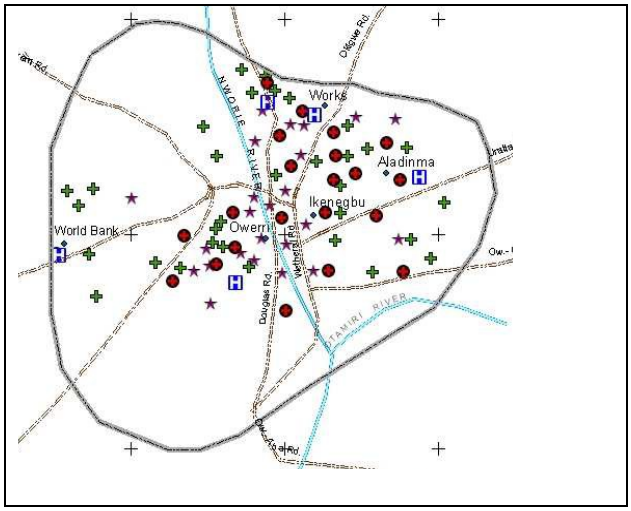
Orodo had nine, and Ezi, Ogbaku, and Ogwa had eight each of the 82 health facilities in Mbaitoli, which was spread across 20 communities. There were 55 primary facilities and 46 privately owned primary facilities, respectively. The 79 facilities ran smoothly.

There were 108 health facilities in Owerri Municipal, distributed throughout the areas, with the bulk (33.3%) in the Ikenegbu region and the least amount (9%), in Works ALyout. 85 private amenities were present. 104 facilities out of the total, or 96.3% of them, were operational. Of the 95 health facilities in Owerri North, which were distributed among 20 settlements, Uratta and Orji had 13.7% and 15.8% of the total, Egbu, Amakohia, and Obibiezena each had 7.4%. There were 63 privately held primary facilities out of 45 primary institutions, with 6.4% owned by missionaries. The 85 amenities functioned properly. Ninety health institutions are dispersed throughout 21 localities in Owerri West, including 17 in Nekede. There were 49 privately owned primary facilities and 56 public primary facilities. The 82 facilities were efficient.

Figure 4(a-c) depicts the Owerri Municipal, Owerri North, and Owerri West LGAs distribution respectively. The majority of healthcare facilities in Owerri Municipal are centered on the north-central locations of the LGA, specifically within the Owerri urban areas. According to directional distribution analysis, the distribution skewed towards clustering along the key routes passing the Owerri North and Owerri West LGAs, indicating a higher spread of healthcare in these axes. This is partly due to the higher population density along the major routes compared to the interior settlements.

Relating communities to the location of health services

As noted earlier, the query that this paper attempts to address is whether the spatial distribution of facilities and the location of services relate to the type of facility in trying to generate information vital for decision-making regarding the planning of health services. Access to health facilities for the population was also recognized in the national population policy as a key ingredient of sustainable development (GoU, 1995).



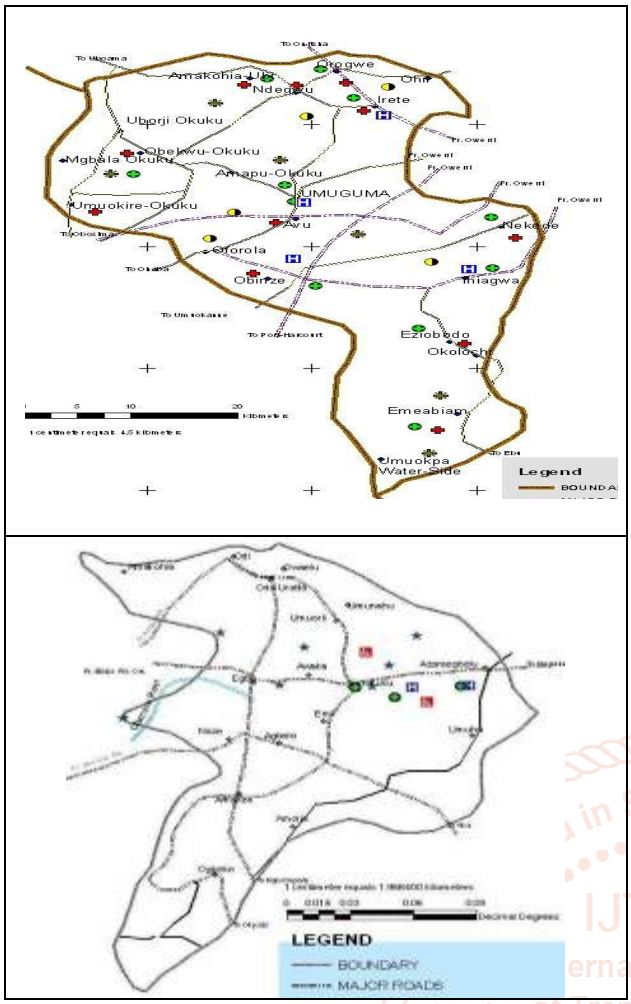


Figure 4: Locations of existing healthcare facilities in different communities of Owerri Municipal, Owerri North, and Owerri West LGAs

Utilizing spatial analysis techniques, the key variables of communities and the number of facilities were plotted to establish any relationships. The result indicated that an increase in population is correlated with an increase in the number of facilities. The relationship using Moran's statistic indicated a weak but significant positive relationship between population and the number of facilities (R2 = 0.193). The explanation is that population although an important variable in planning for facilities including healthcare facilities, is not statistically significant in the historical location of facilities. Consequently, it reveals the need for consideration of the population in locating healthcare services. Further statistical analysis indicated the spatial significance of the relationship between population and the number of facilities calculations ($p < 0.001$) shows a high statistical significance, in areas of high population and high number of health facilities.

The number of healthcare facilities, the population (population estimates for the year 2022), and the land area size in each LGA in Owerri East Senatorial zone are depicted in Table 2.

The ratio of healthcare facilities to population in each LGA could be deduced from Table 1. In the current study, the ratio of healthcare facilities to population was found to range between 1:1571.1 and 1: 4025.6. Results show that Owerri Municipal and Owerri West were the better-served LGA. Since the ratio of the population to healthcare facilities is higher in Ngor Okpala this indicated that the facilities would be overburdened for use.

Table 2: Ratio of number of healthcare facilities, population and the land area size in each LGA in Owerri East Senatorial zone (population estimates for the year 2022),

LGA	Land Area (km^2)	Number of Facilities	Population
Aboh	183.0	111	270,700
Ngor Okpala	523.1	103	219,400
Ahiazu	99.6	68	237,400
Ezinihitte	113.7	71	234,600
Ikeduru	176.5	109	208,100
Mbaitoli	173.4	82	330,100
Owerri Municipal	62.4	108	174,200
Owerri North	167.3	95	245,100
Owerri West	286.8	90	141,400

The spread of the health facilities can be determined by a ratio of the number of healthcare facilities to the land area. The value was found to range from 1: 68 and 1:111. Aboh LGA had the most spread, while Ezinihitte had the least spread. In addition, the population to health care institution ratio in each district was mapped based on the census data that is not in geospatial vector data. Without the coordinate precision, the results on the population-to-institution ratio may not be accurate.

Nevertheless, the findings can be treated as an estimation of the population to health care institution ratio in the LGA. Future studies may want to accurately estimate the population's access to specialized healthcare facilities that includes evaluation of access of the routes to the facilities and the pulling force for siting them.

Conclusion

The distribution of healthcare facilities available in the LGA of Owerri East Senatorial Zone is relatively good with all LGA having from 65 to 108 facilities with 52.2% primary and 47.8% secondary healthcare facilities of which 93% are functional healthcare facilities, the public facilities were estimated at 38% and 62% were for the private sector. The missionaries account for 3.8% of the total facilities in the zone. The density of healthcare facilities distribution was

also found to be proportionate to the LGA population density. This study also exposed the spatial discrepancy of healthcare facilities distribution in the zone. The 837 healthcare facilities in the zone were located in 204 different communities. The location of the facilities mostly falls on the more urban communities like the case of Ikenegbu in Owerri Municipal (36). Spatial accessibility is a major concern to policymakers and planners. Inaccessibility of facilities, lower health services, and spatial arrangement of health facilities at a particular place increase the social and health disparities in society. This indicates the need for quantification of spatial accessibility. The study suggests the use of multi-criteria decision analysis to obtain the optimal site for new healthcare facilities in the disparity region.

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